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Seven new species of *Notiospathius* (Hymenoptera, Braconidae, Doryctinae) from Northwest Venezuela

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Abstract

We describe seven new species of the doryctine wasp genus *Notiospathius* Matthews & Marsh from Northwest Venezuela: *N. araguae* **sp. n.**, *N. bolivari* **sp. n.**, *N. curvilineatus* **sp. n.**, *N. dantei* **sp. n.**, *N. estradae* **sp. n.**, *N. larensis* **sp. n.**, and *N. venezuelae* **sp. n.** These represent the first described species of the genus

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reported for this country. Species boundaries for the above taxa were confirmed using the General mixed Yule-coalescent method with 441 DNA barcode sequences from specimens assigned to *Notiospathius* and other closely related genera collected in different countries along the Neotropics.

Abstract

Se describen siete especies nuevas del género *Notiospathius* Matthews & Marsh para el noroeste de Venezuela: *N. araguae* **sp. n.**, *N. bolivari* **sp. n.**, *N. curvilineatus* **sp. n.**, *N. dantei* **sp. n.**, *N. estradae* **sp. n.**, *N. larensis* **sp. n.**, y *N. venezuelae* **sp. n.** Estas representan las primeras especies descritas del género registradas para Venezuela. La validez de estas especies fue confirmada empleando el método 'General mixed Yule-coalescent' con 441 secuencias del código de barras de especímenes asignados a *Notiospathius* y otros géneros cercanamente relacionados provenientes de varios países del Neotrópico.

Keywords

Barcoding, GMYC model, integrative taxonomy, Neotropical region, parasitoid wasp

Palabras clave

Barcoding, modelo GMYC, taxonomía integral, Neotrópico, avispa parasitoide.

Introduction

The wasp family Braconidae is a group mainly composed of parasitoids that attack a wide range of insect larvae from different orders, but mostly Coleoptera, Diptera and Lepidoptera (Shaw and Huddleston 1991; Marsh 1997). One of the most speciose braconid subfamilies is Doryctinae, with around 200 currently recognised genera and over 1,300 described species (but minimum estimate of 3,000 undescribed species; Jones et al. 2009). Within this subfamily, *Notiospathius* Matthews & Marsh is probably the most speciose genus in the Neotropics after *Heterospilus* Haliday (Ceccarelli et al. 2012). *Notiospathius* was erected to contain 14 species previously placed within the cosmopolitan *Spathius* Nees (Matthews & Marsh, 1973). Currently, the genus comprises 34 Neotropical species (Zaldívar-Riverón and De Jesús-Bonilla 2010; De Jesús-Bonilla et al. 2011), though a considerable, undetermined number of undescribed species remains to be described (Ceccarelli et al. 2012). *Notiospathius* is principally characterised by a considerably enlarged and tubular first metasomal tergite, although this feature is also shared by members of other doryctine genera that are either closely (*Tarasco* Marsh, *Masonius* Marsh) or distantly related (e.g. *Spathius*) to it (Zaldívar-Riverón et al. 2007, 2008; Ceccarelli and Zaldívar-Riverón submitted).

Recently, a number of specimens assigned to *Notiospathius*, *Tarasco* and *Masonius* were collected by three of the authors (AZR, HC, RB) in different localities along northwest Venezuela. In this work, we describe seven new species of *Notiospathius* from this region following an integrative taxonomic approach (Schlick-Steiner et al. 2010; Padial and De la Riva 2010), where both morphological and DNA barcoding (Hebert et al. 2003) data consistently support our species limits. These represent the first described species of the genus recorded for Venezuela.

Methods

Examined specimens

A total of 243 specimens originally assigned to the genera *Notiospathius*, *Masonius* and *Tarasco* were obtained from several localities along four northwest Venezuelan states (Lara, Yaracuy, Carabobo and Aragua). All specimens were collected with yellow pan traps or sweeping nets and preserved in 100% ethanol until they were prepared for DNA extraction. Specimens are deposited in the following collections: Colección Nacional de Insectos, Instituto de Biología, Universidad Nacional Autónoma de México (IB-UNAM CNIN), Museo Entomológico "José M. Osorio", Decanato de Agronomía, Universidad Centroccidental "Lisandro Alvarado", Cabudare, Lara, Venezuela (UCOB), and Departamento de Ecologia e Biologia Evolutiva, Universidade Federal de São Carlos, São Carlos, SP, Brazil (DCBU). The wing venation and sculpture terminologies employed followed Marsh (2002). Digital SEM photographs were taken with a FEI Quanta™ 250 SEM in a low vacuum mode. Colour digital photographs were taken with a Leica® Z16 APO-A stereoscopic microscope and a Leica® DFC295/ DFC290 HD camera, and edited with the Leica application Suite® program.

Species boundaries based on DNA barcodes

We assessed species boundaries among the above Venezuelan specimens by obtaining DNA sequences from the standard animal DNA barcoding locus [cytochrome *c* oxidase I mitochondrial DNA gene (COI)]. DNA extraction, amplification and sequencing for these specimens was carried out at the University of Guelph, Ontario, Canada (see laboratory procedures in Smith et al. 2009). The above sequences are deposited in GenBank (see accession numbers in Table 1) and are also available in the project file "Doryctinae of the world" (DORYC project) of the Barcode of Life Data Systems (BOLD; www.barcodinglife.org). Fourteen sequences of specimens belonging to *Notiospathius* and *Masonius* were also obtained from the BOLD project file "Parasitoid Wasps (Braconidae: Doryctinae) of Chamela–Cuixmala Biosphere Reserve" (ASDOR project; GenBank accession numbers HM434312, 324, 544, 1013-15, 1292, 1293, HQ548183, HQ926041, JF912317-20).

Moreover, we obtained 12 additional sequences of specimens collected in various Neotropical countries (GenBank accession numbers JX870412-23). These sequences were generated at the Instituto de Biología UNAM following the lab procedures described in Ceccarelli et al. (2012). All these sequences were pooled together with a previously published COI data set (Ceccarelli et al. 2012) containing 171 sequences of specimens assigned to *Notiospathius*, *Masonius* and *Tarasco* that were collected in different regions along the Neotropics, and a sequence of *Spathius* that was employed to root the tree.

Species boundaries based on the 441 gathered COI sequences were assessed using the general mixed Yule-coalescent (GMYC) model (Pons et al. 2006; Fontaneto et al. 2007).

Table 1. List of the species delimited in this study, the Venezuelan states* where they were collected, number of representative specimens and GenBank accession numbers.

Species	Venezuelan state	No. specimens	GenBank accession nos
N. araguae sp. n.	Aragua	2	JN266962, 65
N. bolivari sp. n.	Aragua	1	JN266967
N. curvilineatus sp. n.	Lara	2	JN266984-85
N. dantei sp. n.	Yaracuy	1	JN267024
N. estradae sp. n.	Lara	4	JN267030-32, JN870425
N. larensis sp. n.	Lara	3	JN266987, 91, JN870424
N. venezuelae sp. n.	Carabobo, Yaracuy, Heredia*	5	JN266961, 63, 68, JN870300, 400
N. sp. 1	Yaracuy	1	JN267027
N. sp. 2	Aragua, Lara	4	JN266832, 864, 869, 983
N. sp. 3	Lara	2	JN266971, 82
N. sp. 4	Falcón	99	JN266796, 6798, 6799, 6801, 6802, 6879, 6881-6887, 6892-6901, 6904-6907, 6910, 6913-6922, 6924-6930, 6932, 6933, 6935-6938, 6940-6950, 6953-6957, 6992-6998, 7000, 7001, 7003-7016, 7018, JX571911, 12, 14, 18, JN870288, 413, 415, 450
N. sp. 5	Falcón	3	JN266952, 90, JN870414
N. sp. 6	Falcón	15	JN266888-6890, 6891, 6902, 6903, 6908, 6909, 6912, 6931, 6934, 6951, 6999, 7019, JN870416
N. sp. 7	Falcón	7	JN266911, 6923, 6939, 7002, 7017, JN870287, 418
N. sp. 8	Aragua	5	JN266815, 18, 23, 58, 63
N. sp. 9	Aragua, Lara	48	JN266791, 6794, 6806, 6808, 6810-6813, 6816, 6817, 6819-6821, 6826-6830, 6833, 6835, 6841-6844, 6847, 6848, 6850, 6852, 6854, 6861, 6865, 6870-6873, 6960, 6972, 6976, 7035-7041, JX571917, JN870420, JN870292
N. sp. 10	Aragua	34	JN266790, 6792, 6793, 6795, 6809, 6814, 6824, 6825, 6834, 6836, 6840, 6845, 6846, 6849, 6851, 6853, 6855-6860, 6862, 6866, 6867, 6874, 6875, 6877, 6878, 6890, 6974, 7033, 7034, JN870289, 297, 422
N. sp. 11	Aragua	8	JN266805, 838, 969, 970, 978, JN870284, 299, 419
N. sp. 12	Aragua, Falcón	5	JN266822, 39, 80, JN870293, 417
N. sp. 13	Aragua	1	JN266966
N. sp. 14	Yaracuy	3	JN267025, 26, 29
Masonius sp.	Lara	1	JN266973
Tarasco sp. 1	Lara	1	JN266975
Tarasco sp. 2	Yaracuy, Carabobo, Lara	4	JN266789, 7022, 7028, JN870426
Tarasco sp. 3	Aragua	1	JN870423

Species	Venezuelan state	No. specimens	GenBank accession nos
Tarasco sp. 4	Lara	1	JX571925
Tarasco sp. 5	Aragua	2	JN266807, 76
New genus sp. 1	Aragua	3	JN266958, 59, 64
New genus sp. 2	Yaracuy	1	JX870417

* = Costa Rica.

We reconstructed the Bayesian topology required for the above method with the program BEAST version 1.5.3 (Drummond and Rambaut 2007), using a relaxed clock, a coalescent prior for estimating branch lengths and a GTR + I + G model of evolution (Lanave et al. 1984; Yang 1994). We ran the analysis for 20 million generations, sampling trees every 1,000 generations and discarding the first 10,000 sampled trees to ensure that the remaining sampled trees reached stationarity. We built a maximum clade credibility tree with our post-burn-in trees with TreeAnnotator version 1.5.3 (Rambaut and Drummond 2008). The ultrametric tree generated was employed for species delimitation using the SPLITS package for the R statistical environment (http://r-forge.r-project.org/projects/splits) and running the single threshold optimisation (Pons et al. 2006; Monaghan et al. 2009).

Results

Species boundaries analysis

The GMYC analysis based on the ultrametric tree reconstructed with the lognormal coalescent prior is shown in the Supplementary material. The analysis yielded 112 "GMYC" species (confidence interval 100–112; -lnL of null model = 3392.3; -lnL of GMYC model = 3415.7; threshold time = -0.03), 52 of which were recovered as sequence clusters and 60 as singletons. The 267 Venezuelan specimens examined were segregated into 29 GMYC species, of which only one contained specimens from a different country (Costa Rica; *N. venezuelae* sp. n.). Two of these species actually belong to an undescribed genus that is morphologically similar but is distantly related to *Notiospathius* according to a recent multilocus phylogenetic study (Ceccarelli and Zaldívar-Riverón, submitted). Moreover, two separate clades contained most of the examined Venezuelan specimens (232 sequences), one comprising nine (spp. 2-10 in Supplementary Material) and the other one two (spp. 11 and 12) GMYC species, respectively. Species within each of these two clades were morphologically indistinguishable according to our examined features and therefore they will not be described until more evidence is gathered. Other three Venezuelan GMYC species assigned to *Notiospathius* were only represented by males or single, damaged, females, whereas five belong to *Tarasco* and one to *Masonius*. Below we describe the remaining seven GMYC species represented by Venezuelan specimens that also were delimited morphologically. A list with the species delimited in this study, the Venezuelan states where they were collected, number of representative specimens and their GenBank accession numbers is provided in Table 1.

Descriptions

Notiospathius araguae López-Estrada & Zaldívar-Riverón, sp. n.

urn:lsid:zoobank.org:act:BA858D04-A756-4F01-8100-63A34BBFF1A9
http://species-id.net/wiki/Notiospathius_araguae
Figs 1A–E

Diagnosis. This species runs to *N. platycorsus* Marsh in Marsh´s (2002) key to Costa Rican species and its Zaldívar-Riverón and De Jesús-Bonilla's (2010, 2011) extension; however it differs from the latter species by having the propodeum, metapleuron and first metasomal tergite black (mesosoma dark brown, metasoma honey yellow or light brown in *N. platycorsus*); and frons striate (rugose to rugose-costate in *N. platycorsus*).

Description. Female. *Colour*: Head light brown; scape light brown to honey yellow; flagellomeres brown turning dark brown, the last 10 white; palpi pale yellow to white. Mesonotum brown; propodeum, metapleuron and first metasomal tergite black; second and third metasomal tergites brown; remaining metasomal tergites dark brown except two last metasomal tergite, which are honey yellow; ovipositor and sheaths brown. Fore and middle coxae, trochanter and trochantellus pale yellow; femora and tibiae light brown; tarsi dark brown; hind coxa black; trochanter and trochantellus pale yellow; femur, tibia and tarsi ligth brown to brown. Wings dusky; veins and stigma brown; tegula pale yellow. *Body length:* 3.2 mm (lateral view); ovipositor 1.5 mm. *Head:* Clypeus rugose; face, frons and vertex striate, temple and gena smooth; eye about 1.6 times higher than wide (lateral view); malar space 0.1 times eye height (lateral view); temple 0.4 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance four times diameter of lateral ocellus; length of scape twice its width (frontal view); antenna with 26 flagellomeres. *Mesosoma:* Length of mesosoma two times its maximum height; pronotum rugose, lateral area of pronotum coriaceous; pronotal groove wide and scrobiculate; propleuron slightly striate; mesoscutal lobes coriaceous; notauli wide and scrobiculate, meeting in scutellum in a costate area; scutellar disc coriaceous; mesopleural and subalar sulcus continuous, both wide, deep and scrobiculate; mesopleuron porcate dorsally, coriaceous medially and ventrally; precoxal sulcus wide, deep and scrobiculated, as long as mesopleuron; venter of mesosoma slightly coriaceous; metapleuron and propodeum strongly rugose; apical lateral corners without distinct tubercles; spines over hind coxa indistinct. *Wings:* Fore wing length 4.4 times its maximum width; length of pterostigma 3.3 times its maximum width; vein r 0.4 length of vein 3RSa; vein m-cu antefurcal to vein 2RS; vein 1cu-a interstitial to vein 1M; hind wing vein M+CU about 0.3 times length of vein 1M. *Legs:* hind coxa rugose, without basoventral tubercle; middle and hind femora smooth. *Metasoma:* First metasomal tergite rugose, length five times its apical width (dorsal view); basal sternal plate (acrosternite) about 0.7 times length of tergum; second metasomal tergite mostly smooth, only indistinctly costate near basal suture; suture between second and third metasomal tergites indistinct; third metasomal tergite and remaining metasomal tergites smooth and polished; ovipositor about 0.9 times length of metasoma.

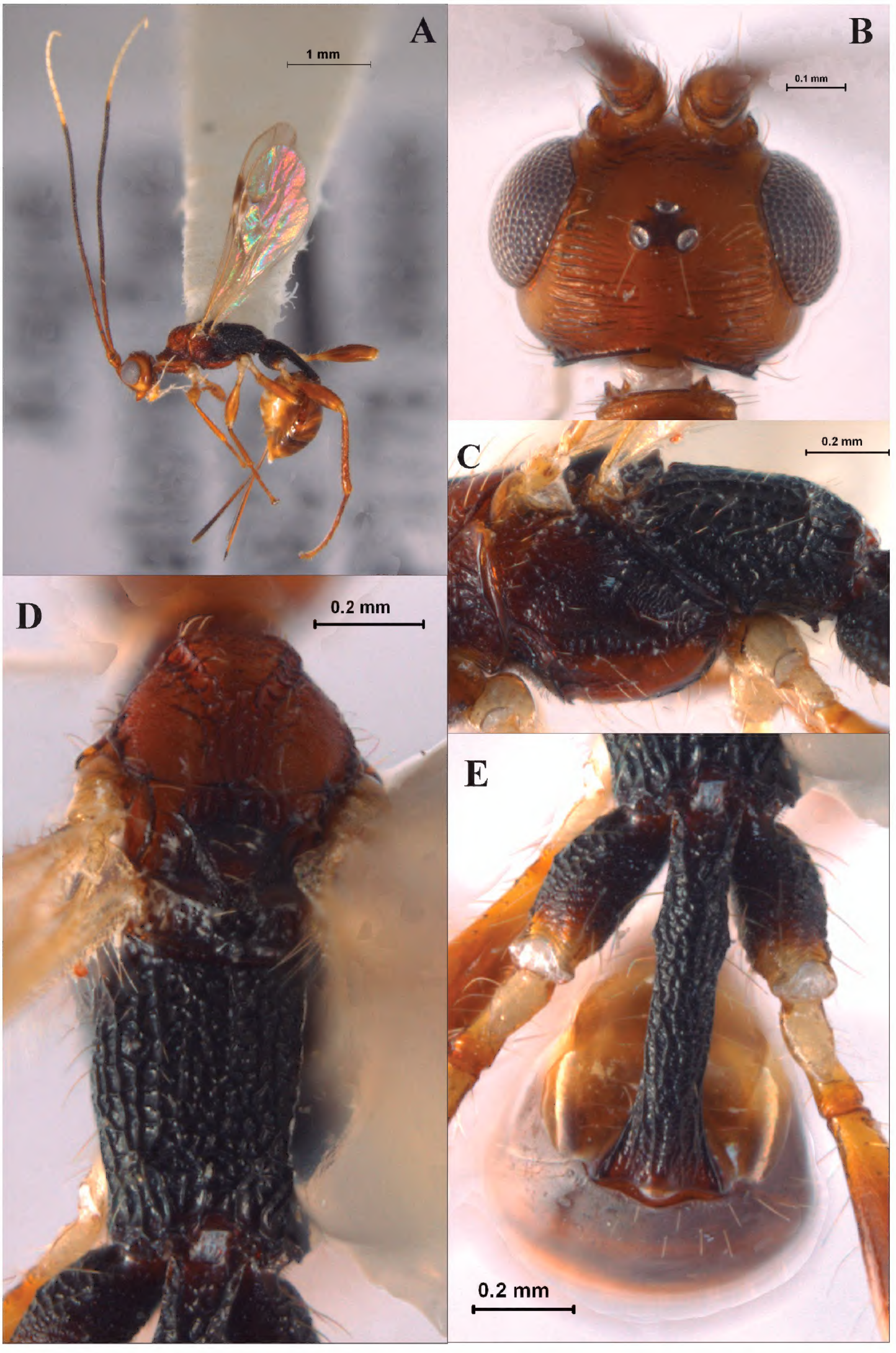

Figure 1. *Notiospathius araguae* sp. n. Female. Holotype: **A** habitus, lateral view **B** head, dorsal view **C** mesosoma, lateral view **D** mesosoma, dorsal view **E** first and second metasomal tergites, dorsal view.

Male. Smaller than female; body length 3 mm; head brown, orbit surrounding eyes yellow; antenna with 23 flagellomeres; second and third metasomal tergites light brown.

Holotype. Female (IB-UNAM CNIN). Venezuela, Aragua, Henri Pittier National Park, 10.37428N, -67.59279W, 1070m, montane cloud forest/riparian, H. Clebsch, 7–11.x.08. DNA voucher no. (BOLD system) DORYC207-11, GenBank accession no. JN266962.

Paratypes. One specimen, male (DCBU). Same data as holotype, DNA voucher no. (BOLD system) DORYC210-11; GenBank accession no. JN266965.

Biology. Unknown.

Etymology. The name of this species refers to the Venezuelan state where both type specimens were collected.

Notiospathius bolivari López-Estrada & Zaldívar-Riverón, sp. n.

urn:lsid:zoobank.org:act:6276E940-C7D2-4177-AEBF-1A9160A570A6
http://species-id.net/wiki/Notiospathius_bolivari
Figs 2A–E

Diagnosis. This new species is morphologically similar to *N. janzeni* Marsh; however, it differs from the latter species by having a basoventral tubercle in the hind coxa (absent in *N. janzeni*) and mesopleuron porcate-coriaceous dorsally, coriaceous ventrally (porcate-rugose dorsally, weakly coriaceous to smooth ventrally in *N. janzeni*). *Notiospathius bolivari* is genetically similar to two species described below, *N. larensis* sp. n. and *N. dantei* sp. n., though it differs from them by having the third metasomal tergite finely striate; and fourth and fifth metasomal tergites finely granulose (third, fourth and remaining metasomal tergites smooth and polished in *N. dantei* sp. n. and *N. larensis* sp. n.).

Description. Female. *Colour:* Head brown; orbit surrounding eye honey yellow; pedicel and scape honey yellow; flagellomeres brown, apical 9 white (one antenna broken); palpi white. Mesonotum brown, venter of mesopleuron and propodeum black; first metasomal tergite black turning brown apically; second metasomal tergite dark brown with two sublateral light brown stripes; third metasomal tergite dark brown; fourth and fifth metasomal tergites dark brown with a semicircular basal area light brown; remaining metasomal tergites dark brown; ovipositor brown, apex strongly sclerotised; sheaths brown, turning dark brown to apex. Fore and middle coxae, trochanter and trochantellus white; femora brown on basal edge, remaining area white with a longitudinal dark brown stripe; tibiae dark brown dorsally, white ventrally; tarsi light brown; hind coxa brown dorsally, dark brown to black ventrally, apical edge white; trochanter and trochantellus white, femur brown on basal edge, basal third white, apical two thirds dark brown with a white irregular area medially; tibia dark brown dorsally, white ventrally; tarsi dark brown. Wings dusky; veins dark brown; stigma dark brown to black, white laterally; tegula honey yellow. *Body length:* 4.2 mm (lateral view), ovipositor 3 mm. *Head:* Clypeus rugose; face, frons and vertex striate-rugose; temple slightly striate; gena smooth; eye 0.8 times higher than wide (lateral view); malar space 0.5 times eye height (lateral view); temple 0.25 times

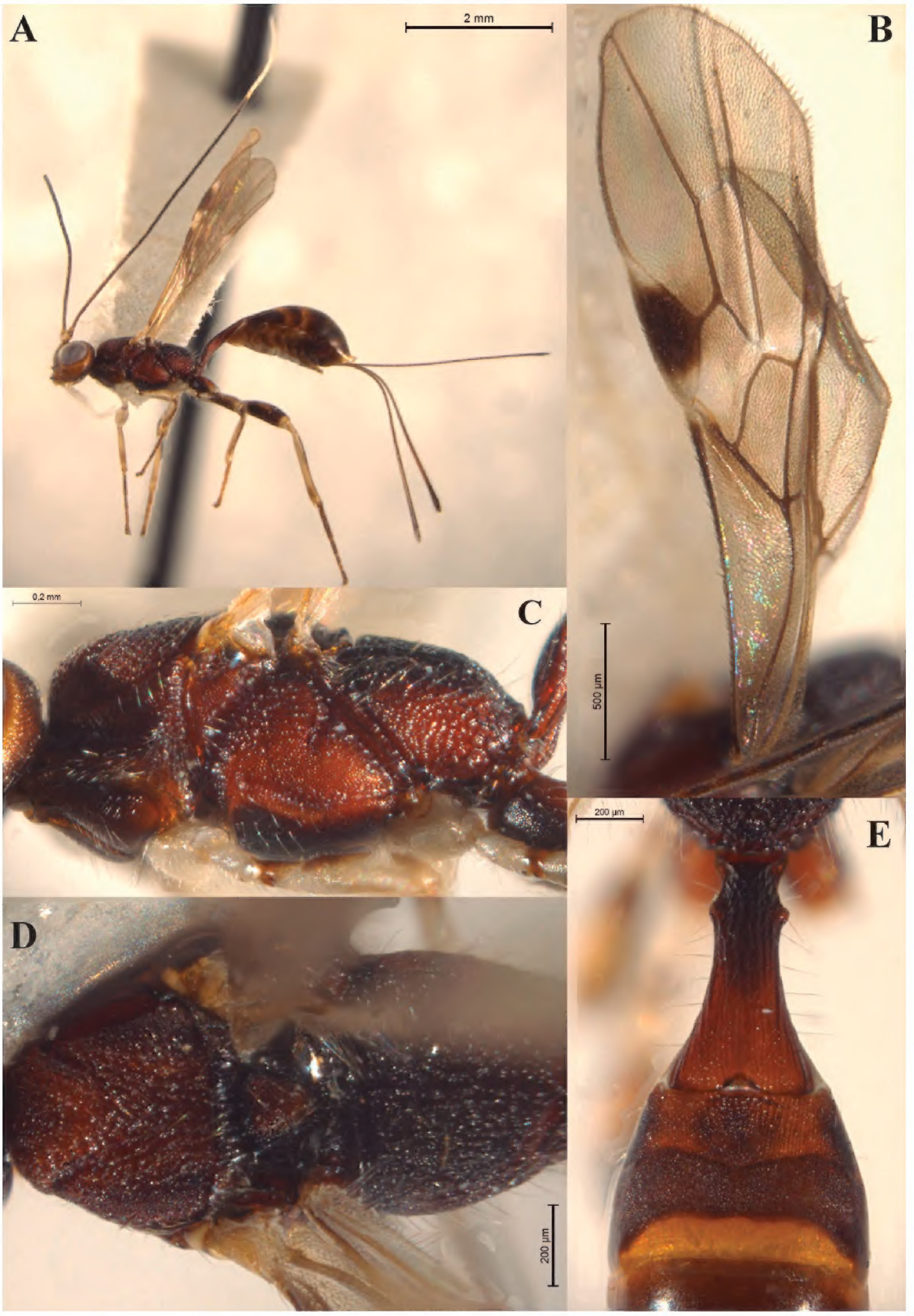

Figure 2. *Notiospathius bolivari* sp. n. Female. Holotype: **A** habitus, lateral view **B** fore wing **C** mesosoma, lateral view **D** metasoma, dorsal view **E** metasoma, dorsal view.

eye width (dorsal view); ocular-ocellar distance 4 times diameter of lateral ocellus; length of scape 2 times its width (frontal view); antenna with 29 flagellomeres (one antenna broken). *Mesosoma:* Length of mesosoma 1.8 times its maximum height; pronotum slightly striate-rugose; pronotal groove wide and scrobiculate; propleuron slightly striate; median mesoscutal lobe striate rugose; lateral mesoscutal lobes striate-rugose, coriaceous medially; notauli wide, deep and scrobiculate, not joining and obscured at middle of mesoscutum in a longitudinally striate-rugose area; scutellar disc coriaceous; subalar and mesopleural sulcus continuous, joining at middle of mesopleuron, the first one wide, deep and scrobiculate, the second one narrow, deep and slightly scrobiculate; mesopleuron porcate-coriaceous dorsally, coriaceous ventrally; precoxal sulcus wide, anterior half shallow and slightly scrobiculated, posterior half deep and scrobiculate, 0.85 as long as mesopleuron; venter of mesosoma coriaceous; metapleuron rugose- areolate, slightly coriaceous anteriorly; propodeum rugose-areolate; apical lateral corners without tubercles; spines over hind coxa absent. *Wings:* Fore wing length 3.3 times its maximum width; length of pterostigma 3.2 times its maximum width; vein r 0.3 length of vein 3RSa; vein m-cu distinctly antefurcal to vein 2RS; vein 1cu-a postfurcal to vein 1M; hind wing vein M+CU 0.7 times length of vein 1M. *Legs:* hind coxa striate dorsally, coriaceous ventrally, with a distinct basoventral tubercle; middle and hind femora coriaceous. *Metasoma:* First metasomal tergite costate with carinate microsculpture, with lateral spine-like projections at basal third of tergite; length 1.6 times its apical width (dorsal view); basal sternal plate (acrosternite) about 0.6 times length of tergum; second metasomal tergite striate with carinate microsculpture; suture between second and third metasomal tergites distinct and sinuate; third metasomal tergite finely striate; fourth and fifth metasomal tergites finely granulose, remaining metasomal tergites smooth and polished; ovipositor about 1.3 times length of metasoma.

Male. Unknown.

Distribution. Northwest Venezuela, state of Aragua.

Holotype. Female (IB-UNAM CNIN). Venezuela, Aragua, Henri Pittier National Park, 10.37428-67.59279, 11-12.ix.07 YPT/78 plates, 1070m Montane cloud forest/riparian, H. Clebsch, DNA voucher no. (BOLD system) DORYC212-11, GenBank accession no. JN266967.

Biology. Unknown.

Etymology. This species is named in honour to Simón Bolívar, the South American military and political leader who led Venezuela, Colombia, Ecuador, Peru and Bolivia to independence.

Notiospathius curvilineatus López-Estrada & Zaldívar-Riverón, sp. n.

urn:lsid:zoobank.org:act:8975DEB8-F0E4-45D0-9A5C-76A12187C839
http://species-id.net/wiki/Notiospathius_curvilineatus
Figs 3A–D

Diagnosis. *Notiospathius curvilineatus* sp. n. is distinguished from the remaining described species of the genus by having a combination of the mesopleuron diagonally

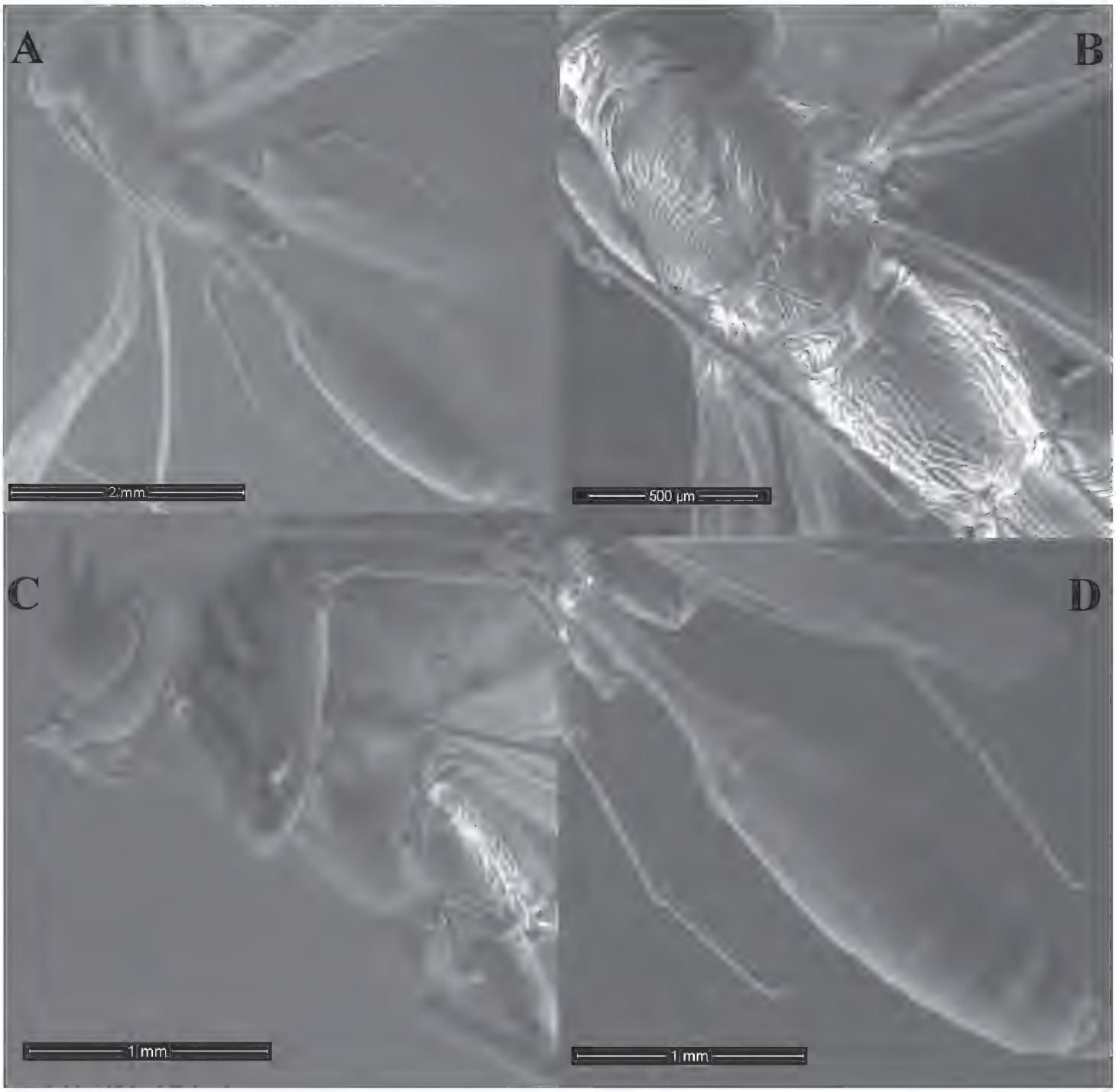

Figure 3. *Notiospathius curvilineatus* sp. n. Female. Paratype: **A** habitus, dorsal view **B** mesosoma, dorsal view **C** mesosoma, lateral view **D** metasoma, dorsal view.

costate from postero-median to medio-ventral region medially and ventrally, and the first three metasomal tergites sculptured. This species runs to *N. janzeni* in Marsh's (2002) key to Costa Rican species and its Zaldívar-Riverón and De Jesús-Bonilla's (2010, 2011) extension; however it differs by having the mesososma and first metasomal tergite reddish brown to brown (mesosoma and first metasomal tergite dark brown to black in *N. janzeni*); hind coxa pale yellow, brown apically (hind coxa dark brown or black in *N. janzeni*); and frons striate (frons rugose in *N. janzeni*).

Description. Female. *Colour*: Head brown to reddish brown; scape pale yellow with a brown longitudinal stripe laterally; flagellomeres dark brown turning black to apex, apical 9 white; palpi white. Mesosoma and first metasomal tergite reddish brown to brown; second metasomal tergite dark brown, yellow basolaterally; third metasomal tergite yellow, dark brown apically; remaining metasomal tergites brown except the last one which is yellow; ovipositor and sheaths brown to reddish brown. Fore and middle

coxae, trochanter and trochantellus pale yellow; femora pale yellow with a median and an apical dark brown transverse bands dorsally; tibiae pale yellow basally, light brown medially and apically, with a dark brown transverse band dorso-basally; tarsi light brown to brown; hind coxa pale yellow, brown apically; trochanter and trochantellus honey yellow; femur pale yellow on basal third, apical two thirds dark brown; tibia pale yellow basally, light brown medially and apically, with a dark brown transverse band dorso-basally; tarsi brown. Wings dusky; veins and stigma dark brown; tegula yellow. *Body length:* 5.8 mm (lateral view); ovipositor 6.8 mm. *Head:* Clypeus rugose; face straite; frons striate; vertex striate; temple and gena smooth; eye 1.5 times higher than wide (lateral view); malar space 0.4 times eye height (lateral view); temple 0.2 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance 2.6 times diameter of lateral ocellus; length of scape 1.4 times its width (frontal view); antenna with 35 flagellomeres. *Mesosoma:* Length of mesosoma 1.9 times its maximum height; pronotum longitudinally costate-coriaceous; pronotal groove wide and slightly scrobiculate; propleuron slightly striate; lateral mesoscutal lobes coriaceous medially, transversally costate along notauli and edges; median mesocutal lobe transversally costate-rugose; notauli wide, deep and scrobiculate, meeting just before scutellum in a longitudinally costate-rugose area; scutellar disc smooth; mesopleural and subalar sulcus discontinuous, the first one deep and scrobiculate and the second one wide, deep and including the striate sculpture of mesopleuron; mesopleuron porcate-slightly coriaceous dorsally, slightly curved, diagonally costate from postero-median to medio-ventral region medially and ventrally; precoxal sulcus wide, deep and including the striate sculpture of mesopleuron, as long as mesopleuron; venter of mesosoma smooth and polished; metapleuron costate ventrally, rugose-aerolate dorsally, slightly coriaceous on anterior first third; propodeum rugose; apical lateral corners without distinct tubercles; spines over hind coxa indistinct. *Wings:* Fore wing length 4.3 times its maximum width; length of pterostigma 2.8 times its maximum width; vein r 0.2 length of vein 3RSa; vein m-cu antefurcal to vein 2RS; vein 1cu-a distinctly postfurcal to vein 1M; hind wing vein M+CU about 0.4 times length of vein 1M. *Legs:* hind coxa striate, indistinct tubercule at the base; middle and hind femora slightly coriaceous. *Metasoma:* First metasomal tergite strongly costate with rugose microsculpture, length 3.1 times its apical width (dorsal view); basal sternal plate (acrosternite) about 0.6 times length of tergum; second metasomal tergite costate with rugose microsculpture; suture between second and third metasomal tergites distinct and sinuate; third metasomal tergite coriaceous on basal half, smooth on apical half; remaining metasomal tergites smooth and polished; ovipositor about 1.8 times length of metasoma.

Male. Unknown.

Variation. Females: *Body length:* close to 5.8 mm; ovipositor about 5.8–6.8. *Head:* Eye 1.4–1.5 times higher than wide (lateral view); scutellar disc slightly coriaceous to smooth. Wings: Fore wing length 4.1–4.3 times its maximum width; length of pterostigma 2.8–3.7 times its maximum width. Metasoma: length of first metasomal tergite 3.1–3.7 times its apical width (dorsal view); ovipositor about 1.6–1.8 times length of metasoma.

Holotype. Female (UCOB). Venezuela, Lara, Parque Nacional Cerro Saroche, sector Cañaote #3, 10°11.83'N, -69°26.13'W, 929 m, 15–19.vii.08, DNA voucher no. (BOLD system) DORYC235-11, GenBank accession no. JN266985.

Paratypes. One female (DCBU). Venezuela, Lara, Parque Nacional Cerro Saroche, La Cimara # 3, 7–10.x.2008, 10°12.656'N, -69°25.339'W, YPT, R. Briceño col., DNA voucher no. (BOLD system) DORYC234-11, GenBank accession no. JN266984.

Biology. Unknown.

Etymology. The name of this species refers to the curved, diagonally costate sculpture on the median and ventral areas of mesopleuron.

***Notiospathius dantei* López-Estrada & Zaldívar-Riverón, sp. n.**
urn:lsid:zoobank.org:act:26384071-6B8F-4AC7-89FC-411C6046796A
http://species-id.net/wiki/Notiospathius_dantei
Figs 4A–D

Diagnosis. This new species is morphologically and genetically similar to one of the species described below, *N. larensis* sp. n., though it differs from the latter species by having the mesonotum reddish brown (brown to dark brown in *N. larensis* sp. n.); first metasomal tergite reddish brown at extreme base, black medially, turning reddish brown to apex (completely black in *N. larensis* sp. n.); and mesopleural and subalar sulcus continuous, joining at middle of mesopleuron (not joining in *N. larensis* sp. n.). *Notiospathius dantei* differs from the remaining described species of the genus with basoventral tubercle on hind coxa by having the following combination of features: first two metasomal tergites sculptured, remaining ones smooth; apical 10 flagellomeres lighter than remaining ones; mesopleuron porcate-sligthly coriacoeus dorsally and medially, coriaceous ventrally; lateral mesoscutal lobes coriaceous medially, striate-rugose laterally; median mesoscutal lobes coriaceous anteromedially.

Description. Female. *Colour:* Head dark brown; area near mandible and orbit surrounding eye honey-yellow; pedicel honey yellow, brown dorsally; flagellomeres brown, turning light brown to apex, apical 10 white (one antenna broken); palpi white. Mesonotum reddish brown to dark brown, first metasomal tergite reddish brown at extreme base, black medially and turning reddish brown to apex; second metasomal tergite dark brown with a semicircular basal area light brown; third and fourth metasomal tergites light brown basally and medially, dark brown apically; remaining metasomal tergites dark brown; ovipositor and sheaths reddish brown, ovipositor apex strongly sclerotized, black. Fore and middle coxae, trochanter and trochantellus white, femora brown at the base, following by white and turning brown to light brown to apex, tibiae and tarsi light brown; hind coxa light brown to brown, trochanter and trochantellus white, femur white at basal third, apical two thirds brown, tibia and tarsi brown. Wings dusky; veins dark brown; stigma pale yellow at extreme base, remaining area dark brown; tegula honey-yellow. *Body length:* 4.1 mm (lateral view), ovipositor

Figure 4. *Notiospathius dantei* sp. n. Female. Holotype: **A** habitus, lateral view **B** metasoma, dorsolateral view **C** mesosoma, lateral view **D** head, dorsal view.

3.7 mm. *Head:* Clypeus striate-rugose; face straite; frons striate-rugose; vertex striate-slightly rugose; temple slightly striate; gena smooth; eye 1.4 times higher than wide (lateral view); malar space 0.4 times eye height (lateral view); temple 0.5 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance 6 times diameter of lateral ocellus; length of scape less than 1.2 times its width (frontal view); antenna with 29 flagellomeres (one antenna broken). *Mesosoma:* Length of mesosoma 1.9 times its maximum height; pronotum striate; pronotal groove wide and scrobiculate; propleuron laterally striate, remaining area slightly coriaceous; lateral mesoscutal lobes coriaceous medially, striate-rugose laterally; median mesoscutal lobes coriaceous anteromedially, remaining area transversally striate-rugose; notauli wide, deep and scrobiculate, not joining, obscuring at middle of mesoscutum in a longitudinally striate-rugose area; scutellar disc slightly coriaceous; mesopleural and subalar sulcus continuous, joining at middle of mesopleuron, the first one deep, narrow and scrobiculate, the second one wide, deep and including the porcate sculpture of mesopleuron; mesopleuron porcate-sligthly coriacoeus dorsally and medially, coriaceous ventrally; precoxal sulcus wide, deep and scrobiculate, as long as mesopleuron; venter of mesosoma slightly coriaceous; metapleuron longitudinally costate with rugose microsculpture;

propodeum longitudinally costate-rugose; apical lateral corners with tubercles; spines over hind coxa absent. *Wings:* Fore wing length 4.1 times its maximum width; length of pterostigma 3.2 times its maximum width; vein r 0.3 length of vein 3RSa; vein m-cu distinctly antefurcal to vein 2RS; vein 1cu-a slightly postfurcal to vein 1M; hind wing vein M+CU 0.4 times length of vein 1M. *Legs:* hind coxa striate, with an almost indistinct basoventral tubercle; middle and hind femora slightly coriaceous. *Metasoma:* First metasomal tergite costate with rugose microsculpture; length 2.3 times its apical width (dorsal view); basal sternal plate (acrosternite) about 0.7 times length of tergum; second tergite striate with rugose microsculpture; suture between second and third metasomal tergites distinct and slightly sinuate; remaining metasomal tergites smooth and polished; ovipositor about 1.7 times length of metasoma.

Male. Unknown.

Distribution. Northwest Venezuela, state of Yaracuy.

Holotype. Female (IB-UNAM CNIN). Venezuela, Yaracuy, Est. Biol. Guáquira, 10°17.84'N, -68°39.32'W, 107 m, sweep, selva trop., DNA voucher no. (BOLD system) DORYC278-11, GenBank accession no. JN267024.

Biology. Unknown.

Etymology. This species is named in honour of the first author's father.

Notiospathius estradae López-Estrada & Zaldívar-Riverón, sp. n.

urn:lsid:zoobank.org:act:52FF943B-8C41-4823-8DB3-F18BC9602BCC
http://species-id.net/wiki/Notiospathius_estradae
Figs 5A–D

Diagnosis. This species is similar to *N. shawi* Marsh, though it can be distinguished from the latter species by having the mesopleuron coriaceous-slightly rugose dorsally, coriaceous medially and ventrally (costate dorsally and coriaceous ventrally in *N. shawi*), and notauli obscuring before scutellum in a large porcate-rugose area (meeting before scutellum in a narrow rugose area in *N. shawi*).

Description. Female. *Colour*: Head light brown to honey yellow; scape honey yellow; flagellomeres honey yellow turning dark brown to apex; palpi pale yellow. Mesosoma and first metasomal tergite black, pronotum light brown on half basal half, black on apical half; second metasomal tergite dark brown; third metasomal tergite and remaining metasomal tergites brown to dark brown; last one pale yellow; ovipositor brown; sheaths honey yellow. Fore and middle coxae light brown to honey yellow; trochanter and trochantellus pale yellow; femora brown; tibiae pale yellow basally, honey yellow medially and apically; tarsi honey yellow; hind coxa black; trochanter and trochantellus pale yellow; femur dark brown; tibia pale yellow basally turning light to apex; tarsi light brown. Wings dusky, veins and stigma dark brown, tegula dark brown to black. *Body length:* 4.4 mm (lateral view); ovipositor 3.8 mm. *Head:* Clypeus rugose; face, frons and vertex striate; temple and gena smooth; eye about 0.9 times higher than wide (lateral view); malar space 0.6 times eye height (lateral view); temple 0.2 times

Figure 5. *Notiospathius estradae* sp. n. Female. Paratype: **A** habitus, lateral view **B** mesosoma, dorsal view **C** mesosoma, lateral view **D** metasoma, dorsal view.

eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance 1.5 times diameter of lateral ocellus; length of scape twice its width (frontal view); antenna with 29 flagellomeres. *Mesosoma:* Length of mesosoma 1.9 times its maximum height; pronotum coriaceous; pronotal groove narrow and slightly scrobiculate; propleuron slightly striate; mesoscutal lobes coriaceous; notauli wide and scrobiculate, not joining, obscuring in a large porcate-rugose area; scutellar disc coriaceous; mesopleural and subalar sulcus continuous, both deep and scrobiculate; mesopleuron coriaceous-slightly rugose dorsally, coriaceous medially and ventrally; precoxal sulcus wide, deep

and scrobiculate, as long as mesopleuron; venter of mesosoma coriaceous; metapleuron and propodeum strongly rugose with coriaceous microsculpture; apical lateral corners without distinct tubercles; spines over hind coxa indistinct. *Wings:* Fore wing length 4.3 times its maximum width; length of pterostigma 3.6 times its maximum width; vein r 0.3 length of vein 3RSa; vein m-cu intersticial to vein 2RS; vein 1cu-a distinctly postfurcal to vein 1M; hind wing vein M+CU about 0.5 times length of vein 1M. *Legs:* hind coxa coriaceous, with a distinct basoventral tubercle; middle and hind femora smooth. *Metasoma*: First metasomal tergite strongly costate with rugose microsculpture, length twice its apical width (dorsal view); basal sternal plate (acrosternite) about 0.5 times length of tergum; second metasomal tergite costate with rugose microsculpture; suture between second and third metasomal tergites distinct and sinuate; third metasomal tergite costate on basal half, smooth on apical half; remaining metasomal tergites smooth and polished; ovipositor about 1.8 times length of metasoma.

Male. Unknown.

Variation. Females: *Colour:* head dark brown; orbit surrounding eyes yellow. *Body length:* 4.4–5.4 mm (lateral view); ovipositor 3.6–4.2 mm. *Head:* Eye 0.9–1.3 times higher than wide (lateral view). *Wings:* Fore wing length 4.2–4.6 times its maximum width; length of pterostigma 2.8–3.6 times its maximum width. *Metasoma:* length of first metasomal tergite 1.3–2.0 times its apical width (dorsal view); ovipositor 1.5–1.8 times length of metasoma.

Holotype. Female (UCOB). Venezuela, Lara, Parque Nacional Cerro Saroche, sector Batatal # 4, 10°09.15'N, -69°30.205'W, 809 m, 7–11.x.08, DNA voucher no. (BOLD system) DORYC286-11; GenBank accession no. JN267031.

Paratypes. Three females (IB-UNAM CNIN). Same data as holotype, DNA voucher nos (BOLD system) DORYC285-11, DORYC 287-11, IB-CNIN569, GenBank accession nos JN267030, JN267032, JN870425.

Biology. Unknown.

Etymology. We named this species in honour to the first author's mother, Margarita Estrada.

***Notiospathius larensis* López-Estrada & Zaldívar-Riverón, sp. n.**
urn:lsid:zoobank.org:act:90728947-9EBB-432D-B51C-8AAF57F3C73A
http://species-id.net/wiki/Notiospathius_larensis
Figs 6A–D

Diagnosis. This species is morphologically similar to *N. dantei*, but they differ by the morphological features mentioned in the diagnosis of the latter species. *Notiospathius larensis* differs from the remaining species of the genus with basoventral tubercle on the hind coxa by having the following combination of features: vertex rugose-striate; mesoscutal lobes coriaceous medially, striate-rugose laterally or anteromedially; mesopleuron porcate dorsally, rugose-coriaceous to coriaceous medially and ventrally; first two metasomal tergites scultpured, remaining ones smooth.

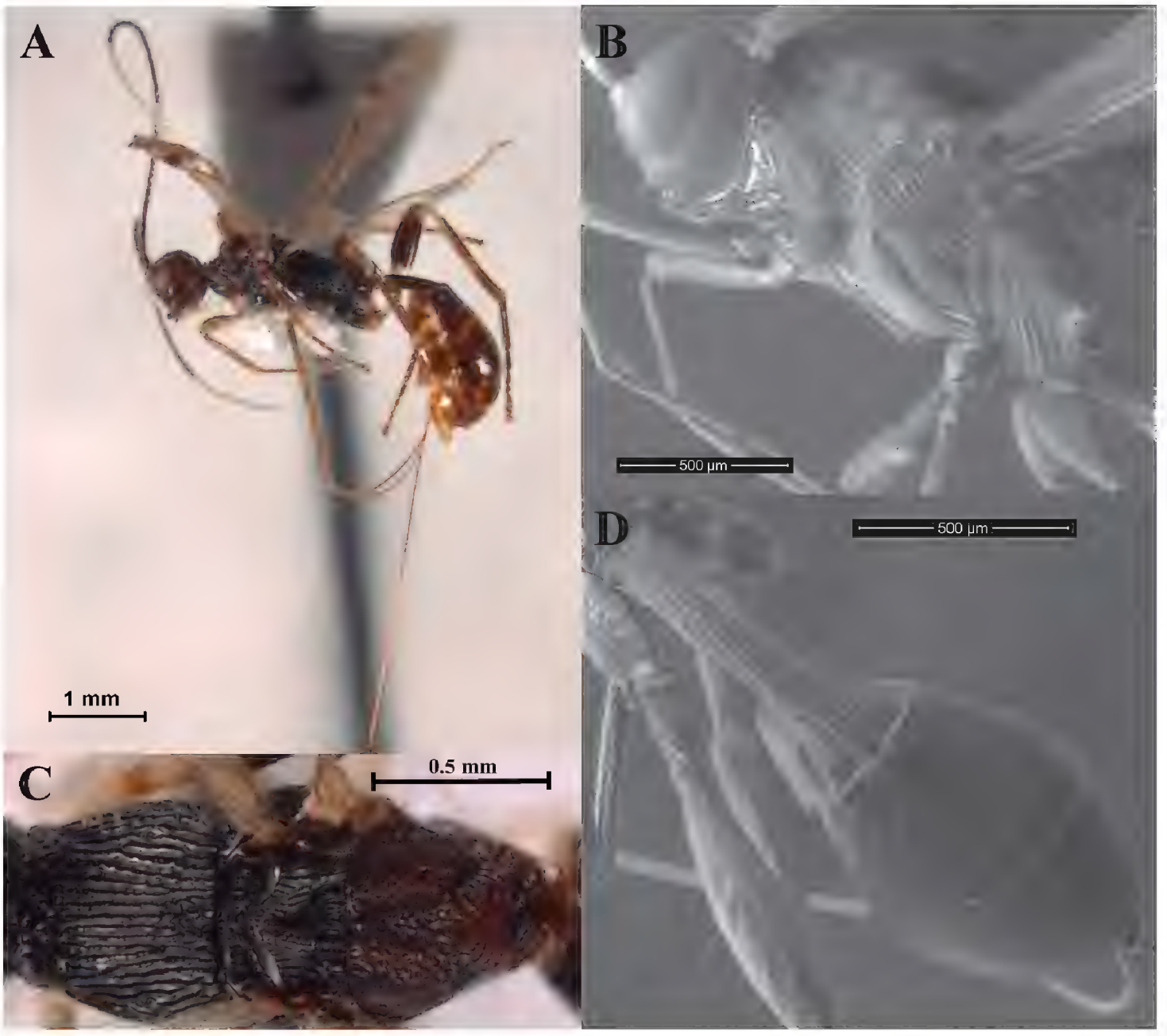

Figure 6. *Notiospathius larensis* sp. n. Female. Holotype: **A** habitus, lateral view **B** mesosoma, lateral view **C** mesosoma, dorsal view **D** metasoma, dorsal view.

Description. Female. *Colour:* Head brown; orbit surrounding eyes yellow; scape and pedicel light brown; flagellomeres brown, apical 10 white (broken); palpi white. Mesonotum brown to dark brown; propodeum, metapleuron and first metasomal tergite black, brown apically; second metasomal tergite dark brown with a light brown basal semicircular area; third and fourth metasomal tergites brown; remaining metasomal tergites brown to light brown, ovipositor and sheaths brown to honey yellow, ovipositor apex strongly sclerotized, black. Fore and middle coxae white; trochanter and trochantellus pale yellow; fore femur light brown; middle femur brown; fore and middle tibia and tarsi light brown; hind coxa dark brown; trochanter and trochantellus honey yellow; femur honey yellow at basal first third, apical two thirds dark brown; tibia brown; tarsi dark brown. Wings dusky, veins and tegula honey yellow; stigma yellow at basal third, dark brown apically. *Body length:* 4.2 mm (lateral view), ovipositor 3.3 mm. *Head:* Clypeus straite-rugose; face striate; frons rugose; vertex rugose-striate; temple weakly striate dorsally, gena smooth; eye 1.1 times higher than wide (lateral view); malar space almost 0.4 times eye height

(lateral view); temple 0.2 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance 3 times diameter of lateral ocellus; length of scape less than 1.5 times its width (frontal view); antenna with 30 flagellomeres (broken). *Mesosoma:* Length of mesosoma 1.9 times its maximum height; pronotum striate dorsally, slightly rugose ventrally; pronotal groove, wide and scrobiculate; propleuron striate; lateral mesoscutal lobes coriaceous medially, striate-rugose laterally; median mesoscutal lobe coriaceous anteromedially, remaining area striate-rugose; notauli scrobiculate, not joining, obscuring in a longitudinally striate-rugose area; scutellar disc coriaceous; mesopleural and subalar sulcus discontinuous, both deep and narrow; mesopleuron porcate dorsally, including subalar area, rugose-coriaceous antero-ventrally, coriaceous ventrally; precoxal sulcus wide, deep and scrobiculate, as long as mesopleuron; venter of mesosoma slightly coriaceous; metapleuron striate; propodeum longitudinally striate; apical lateral corners with distinct tubercles; spines over hind coxa indistinct. *Wings:* Fore wing length 5.1 times its maximum width; length of pterostigma three times its maximum width; vein r 0.5 length of vein 3RSa; vein m-cu antefurcal to vein 2RS; vein 1cu-a distinctly postfurcal to vein 1M; hind wing vein M+CU 0.4 times length of vein 1M. *Legs:* fore tibia with a row of at least seven spines; hind coxa striate, with a distinct basoventral tubercle; middle and hind femora slightly striate. *Metasoma:* First metasomal tergite strongly rugose anteriorly, costate with rugose microsculpture medially and posteriorly, length three times its apical width (dorsal view); basal sternal plate (acrosternite) about 0.7 times length of tergum; second metasomal tergite striate; suture between second and third metasomal tergites distinct and straight; remaining metasomal tergites smooth and polished; ovipositor about 1.6 times length of metasoma.

Male. Unknown

Variation. Females: *Head*: scape and pedicel with a brown stripe laterally *Body length:* close to 4.0–4.2 mm; ovipositor about 3.3–3.8. *Head:* Eye 1.1–1.4 times higher than wide (lateral view). Wings: Fore wing length 3.8–4.1 times its maximum width; length of pterostigma 3.0–3.5 times its maximum width. *Metasoma*: length of first metasomal tergite 2.6–3.0 times its apical width (dorsal view).

Holotype. Female (UCOB). Venezuela, Lara, Parque Nacional Cerro Saroche, sector Batatal, 10°09.15'N, -69° 30.205'W, 809 m, 15–19.vii.2008, YTP, R. Briceño col., DNA voucher no. IB-CNIN567; GenBank accession no. JN870424.

Paratypes. Two females (IB-UNAM CNIN, DCBU). One female, Venezuela, Lara, Parque Nacional Cerro Saroche, La Cimara #5, 10°12.656'N, -69°25.339'W, 7-10.x.2009, R. Briceño col., DNA voucher no. (BOLD systems) DORYC241-11; GenBank accession no. JN266991; one female, Venezuela, Lara, Parque Nacional Cerro Saroche, Cañaote #3, 10°11.83'N, -69°26.13'W, 929 m, 15–19.vii.08, col. R. Briceño, DNA voucher no. (BOLD systems) DORYC237-11; GenBank accession no. JN266987.

Biology. Unknown.

Etymology. The name of this species refers to the Venezuelan state where the species was collected.

***Notiospathius venezuelae* López-Estrada & Zaldívar-Riverón, sp. n.**
urn:lsid:zoobank.org:act:4C4BD7CE-586B-4142-BA7A-CC22284E094B
http://species-id.net/wiki/Notiospathius_venezuelae
Figs 7A–E

Diagnosis. This species runs to *N. leucacrocera* (Enderlein) in the extension (Zaldívar-Riverón and De Jesús-Bonilla 2010, 2011) to Marsh's (2002) key to Costa Rican species. However, it differs from the latter species by having the mesosoma and first metasomal tergite mostly black (mesosoma and first metasomal tergite dark brown in *N. leucacrocera*); fore and middle coxae white, femora pale yellow on basal third, brown on apical two thirds; (fore and middle legs completely yellow in *N. leucacrocera*), pronotum and propleuron coriaceous and striate, respectively (pronotum and propleuron costate in *N. leucacrocera*). *N. venezuelae* can be distinguished from the remaining described species of the genus by having the following combination of features: hind coxa black, pale yellow apically; pronotum coriaceous; mesoscutal lobes coriaceous; notauli not joining, obscuring in a large costate area; mesopleuron porcate-coriaceous dorsally, coriaceous medially and ventrally.

Description. Female. *Colour*: Head dark brown to black; orbit surrounding eyes yellow; scape light brown, with a brown stripe; flagellomeres dark brown, last 11 white; palpi white. Mesosoma and first metasomal tergite black except pronotum wich is brown; second metasomal tergite dark brown; third, fourth and fifth metasomal tergites brown with a light brown band at the middle; sixth metasomal tergite dark brown, pale yellow in apex; remaining metasomal tergites pale yellow; ovipositor brown; sheaths pale yellow turning dark brown. Fore and middle coxae and trochanter white, trochantellus brown, femora pale yellow on basal third, brown on apical two thirds, pale yellow apically, tibiae light brown, tarsi brown; hind coxa black, pale yellow apically; trochanter pale yellow; trochantellus brown; femur white to pale yellow on basal third, brown on apical two thirds, pale yellow at extreme apex; tibia pale yellow basally, turning light brown apically; tarsi brown. Wings dusky; veins and stigma brown; tegula light brown. *Body length:* 4.1 mm (lateral view), ovipositor 1.6 mm. *Head:* Clypeus rugose; face, frons and vertex striate; temple slightly striate; gena smooth; eye about 1.1 times higher than wide (lateral view); malar space 0.2 times eye height (lateral view); temple 0.2 times eye width (dorsal view); hypoclypeal depression elliptic; ocular-ocellar distance three times diameter of lateral ocellus; length of scape twice its width (frontal view); antenna with 28 flagellomeres. *Mesosoma:* Length of mesosoma 2.1 times its maximum height; pronotum coriaceous; pronotal groove wide and coriaceous; propleuron striate; mesoscutal lobes coriaceous; notauli narrow, scrobiculate and with coriaceous microsculpture, not joining, obscuring in a large costate area; scutellar disc coriaceous; mesopleural and subalar sulcus continuous, both scrobiculate; mesopleuron porcate-coriaceous dorsally, coriaceous medially and ventrally; precoxal sulcus narrow, deep and scrobiculated, as long as mesopleuron; venter of mesosoma coriaceous; metapleuron and propodeum costate with rugose microsculpture; apical lateral corners with distinct tubercles; spines over hind coxa distinct. *Wings:* Fore

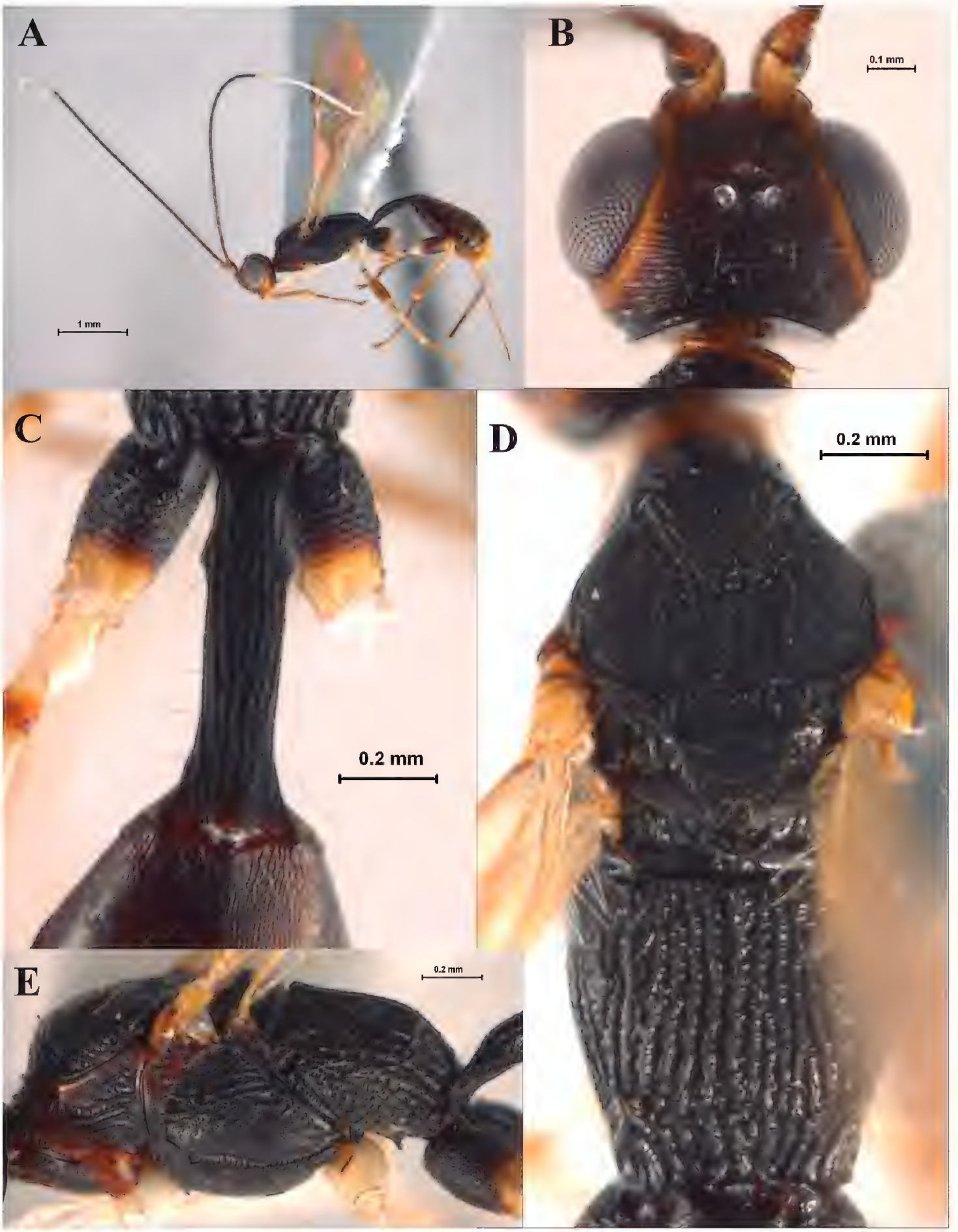

Figure 7. *Notiospathius venezuelae* sp. n. Female. Holotype: **A** habitus, lateral view **B** head, dorsal view **C** first and second metasomal tergites, dorsal view **D** mesosoma, dorsal view **E** mesosoma, lateral view.

wing length 5.1 times its maximum width; length of pterostigma 3.3 times its maximum width; vein r 0.3 length of vein 3RSa; vein m-cu antefurcal to vein 2RS; vein 1cu-a distinctly antefurcal to vein 1M; hind wing vein M+CU about 0.5 times length of vein 1M. *Legs:* hind coxa rugose at the base, striate posteriorly, indistinct tubercule

at the base; middle and hind femora coriaceous. *Metasoma:* First metasomal tergite strongly costate with rugose microsculpture, length 3.2 its apical width (dorsal view); basal sternal plate (acrosternite) about 0.7 times length of tergum; second metasomal tergite slightly costate; suture between second and third metasomal tergites distinct and sinuate; third metasomal tergite smooth; remaining metasomal tergites smooth and polished; ovipositor about 0.7 times length of metasoma.

Male. Essentially as female; pronotum light brown; third and fourth metasomal tergites light brown with a honey yellow band at the middle; antenna with 24 flagellomeres dark brown, only last three white.

Variation. Females: *Body length:* 2.8–4.1 mm (lateral view), ovipositor 1.0–1.6 mm. *Head:* Eye 1.1–1.2 times higher than wide (lateral view); malar space 3.3–4.5 mm *Wings:* Fore wing length 4.2–5.1 times its maximum width, length of pterostigma 2.8–3.6 times its maximum width. *Metasoma:* length of first metasomal tergite 3.2–3.6 times its apical width (dorsal view).

Holotype. Female (IB-UNAM CNIN). Venezuela, Carabobo, Palmichal, 10.28590N, -68.23993W, 93m, 30–3.viii.07, YTP/68 plates, shade coffee, orange grove, H. Clebsch, L. García col., DNA voucher no. (BOLD system) DORYC208-11; GenBank accession no. JN266963.

Paratypes. Four specimens, three males, one female (IB-UNAM CNIN, UCOB). One female and two male, same data as holotype, DNA voucher nos (BOLD system) DORYC206-11, DORYC213-11, GenBank accession nos JN266961, JN266968; one male, Venezuela Yaracuy Mpio. San Felipe, Est. Biol. Guáquira, 107 m, 10°17.84N, -68°39.32W, sweep, 11:00 am, selva tropical, DNA voucher no. IB-CNIN-396, GenBank accession no. JN870300; one male, Costa Rica, Heredia, 11 km ESE La Virgen, 10°21'N, -84°03'W, 20-II-2004, INBIO-OET transect, 250-350 m, DNA voucher no. IB-CNIN537, GenBank accession no. JN870400.

Biology. Unknown.

Etymology. We have named this species after the country where most of the specimens of this new species were collected.

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Appendix

Species delimitation using the GMYC method. doi: 10.3897/JHR.29.3555.app

Explanation note: Ultrametric tree derived from the BEAST analysis showing the species boundaries recovered with the GMYC model and the SPLITS program for 441 DNA barcoding sequences belonging to specimens assigned to *Notiospathius*, *Tarasco* and *Masonius* that were collected in different localities along the Neotropics. Black terminal branches refer to species represented by a single specimen (singletons). Species represented by sequence clusters are coloured in red. Codes of terminal taxa: DORYC = BOLD process ID for Venezuelan specimens; Arg = Argentina; Bra = Brazil; Col = Colombia; Cri = Costa Rica; Cub = Cuba; Dom = Dominican Republic; Ecu = Ecuador; Fgu = French Guyana; Moa = Mexico, Oaxaca; Mve = Veracruz, Mexico; Tri = Trinidad and Tobago; Ven = Venezuela; Spat = *Spathius*.

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